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MOVEMENT AND MORTALITY PATTERNS OF BLACK DUCKS AND MOUNTAIN DUCKS BANDED IN VICTORIA

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ABSTRACT: Between 1952 and 1969, 5644 Black Ducks and 3798 Mountain Ducks were banded in Victoria. Of these 1461 (25·9 per cent) Black Ducks and 749 (19·7 per cent) Mountain Ducks were recovered to the end of 1969; of those banded 20·8 and 17·2 per cent were shot. By combination of data for all years it is shown that most recoveries were within a year of banding and that the corresponding mortality rate was highest (67·3 per cent for Black Ducks and 48·8 per cent for Mountain Ducks) in the first year after banding. Within four years 93·3 per cent mortality occurred in Black Ducks and 90·4 per cent in Mountain Ducks, with calculated life expectancies being 1·26 and 1·44 years respectively. Life expectancy was greater in males than females, and this held for juveniles which have a higher mortality rate in the year following banding than other groups. However, juveniles and females contained less shotgun pellets than males when fluoroscopically examined; of Black Ducks examined 13·8 per cent carried shot as did 22·3 per cent of the Mountain Ducks.

Calculations based on the average mortality rates indicate that Black Ducks must produce four, and Mountain Ducks two, young per pair annually, to maintain their average population sizes and to sustain the present mean hunting pressure. Though few data are available this would appear feasible for both species, which disperse widely within this state. Habitat preservation will become more important and since there is a movement into and out of the State, conservation will depend in part on co-operative measures.

INTRODUCTION

Amongst the major game species of waterfowl in Victoria, Black Duck *Anas superciliosa* Gmelin, Grey Teal *A. gibberifrons* Müller and Chestnut Teal *A. castanea* (Eyton) form a large portion of the annual harvest of ducks taken during open (shooting) seasons. And although not generally considered important as a game species, the Mountain Duck *Tadorna tadornoides* (Jardine and Selby) is shot both widely and in large numbers. Black Ducks and Mountain Ducks differ in their preferred habitat requirements, though both are extensively distributed. Whereas Black Ducks generally inhabit deeper, more permanent and well-vegetated wetlands, Mountain Ducks are usually seen on or near open wetland areas in coastal regions and inland plains (Frith 1967, Wheeler 1967). Blacks Ducks have a predominantly vegetarian diet (Frith 1959, 1967, Frith, Braithwaite & McKean 1969) but apparently Mountain Ducks are more omnivorous, eating invertebrates, small vertebrates and plant material (Frith 1967). Mountain Ducks are particularly numerous in Western Victoria where large flocks cause occasional localized damage to growing crops and pastures.

Little is known about the movement or mortality patterns of Black Ducks or Mountain Ducks in Victoria. Banding provides a convenient method of determining such aspects of waterfowl ecology and can thus be used to aid management procedures. It is the purpose of this paper to summarize results relating to these species obtained following banding operations conducted by the Victorian Fisheries and Wildlife Department between 1952 and 1969. Results obtained for other species have been reported elsewhere (Norman 1970, 1971b).

METHODS

Black Ducks and Mountain Ducks were trapped at various localities in Victoria using baited traps similar to those described by McNally and Falconer (1953). Traps were generally set close to water, and birds when caught were transferred to holding cages. During banding birds were usually sexed and aged using cloacal examination (Hoch-

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baum 1942). Plumage characteristics also were recorded although few females were aged by this procedure.

Bands from birds found dead (recovered) were forwarded to the Fisheries and Wildlife Department. The recovery details were recorded and coded, punched on data cards, collated with banding information (see Downes 1971, for additional details) and then analysed using computer tabulations. Data discussed below relate to Black Duck banded between 1952 and 1969, and Mountain Duck banded between 1954 and 1967, which were recovered to 31 December 1969. When incomplete recovery information was received, attempts were made to elicit further details. Such information was not always obtained and hence there is variation in totals presented in the tables given below. Mortality and associated data have been calculated by methods outlined by Balham and Miers (1959), Bellrose and Chase (1950), Hickey (1952) and Reid (1966). Weighted mean annual mortality has been computed following Farner (1955) and Balham and Miers (1959).

Since 1957, samples of trapped birds were examined for the presence of shot pellets using an X-ray fluoroscope of the type described by Elder (1955) and Bellrose (1959). Whilst many birds were recaptured and examined more than once, totals given below refer only to the initial fluoroscopic examination.

RESULTS

(i) BANDING TOTALS

Between 1952 and 1969, 5644 Black Ducks were banded at 29 sites in Victoria. Of these, 3932 (69·7 per cent) were trapped during the more continuous operations conducted at Serendip, the Fisheries and Wildlife Research Station, near Geelong. Annual banding totals have varied between 5 (1963) and 1743 (1953). Of the 3798 Mountain Ducks caught at 15 localities in Victoria between 1954 and 1967, 1816 were caught at Lake Martin and 1081 at Lake Rosine, both at the northern end of Lake Corangamite near Cressy in Western Victoria. A further 474 were trapped at Serendip. Annual totals varied between nil (1953) and 1923 (1960).

(ii) SEX AND AGE TOTALS

Of the Black Ducks banded, 1980 were males, 1850 females and 1814 were released without being sexed; of those sexed 51·7 per cent were males. Table 1 gives details of annual catches made at Serendip since 1952, and since few females were aged, the adult to juvenile proportion shown has been based on capture of males only. The percentage of males in the sexed total is also given, as are the numbers of birds released without sexing.

Males comprised 53·0 per cent of the Black

TABLE 1

Annual totals of Black Ducks caught at Serendip between 1952 and 1969. Sex composition, the number of birds released without sexing, and the adult : juvenile male percentages are also given.

Year	Totals						Percent	
	Caught (all groups)	*Male*	*Female*	*Adult male*	*Juvenile male*	*Not sexed*	*Male*	*Adult male*
1952	443	2	1	—	1	441	66·6	—
1953	1181	335	455	234	79	371	43·8	74·8
1954	1	—	—	—	—	1	—	—
1955	34	2	3	2	—	29	40·0	100
1956	179	85	79	24	46	15	51·8	34·3
1957	205	70	59	25	4	76	54·3	86·2
1958	80	42	38	36	3	3	52·5	92·3
1959	29	13	16	—	13	—	44·8	—
1960	19	10	9	10	—	—	52·6	100
1961	79	43	36	21	12	—	54·4	63·6
1962	112	68	43	53	12	1	61·3	81·5
1963	—	—	—	—	—	—	—	—
1964	410	235	173	163	69	2	57·6	70·3
1965	369	221	140	115	106	4	61·2	52·0
1966	358	194	159	145	49	5	55·0	74·7
1967	339	185	154	76	109	—	54·6	41·1
1968	22	15	7	8	7	—	68·2	53·3
1969	72	50	22	37	13	—	69·4	74·0
Totals	3932	1570	1394	949	523	948	53·0	64·5

Ducks sexed at Serendip since 1952, with almost 113 males being trapped for every 100 females. Juvenile birds made up 35·5 per cent of the catch of male birds, i.e. adult to juvenile ratio of 1:0·55.

Of the 3798 Mountain Ducks processed between 1954 and 1967, 1422 were males, 2278 females and 98 were released without being sexed; of the sexed total only 38·4 per cent were males. Few females were aged at banding but the adult to juvenile male ratio was 1:0·6.

(iii) RECOVERIES

To the end of 1969, 1461 bands have been returned from recovered Black Ducks, i.e. 25·9 per cent of the banded total. Shooting was recorded as the cause of death for 1176 (80·5 per cent) of these recoveries and thus of 20·8 per cent of birds banded. Males made up 55·5 per cent of birds sexed at banding and later recovered.

For Mountain Ducks, 749 bands were returned to the end of 1969, i.e. a 19·7 per cent return for the banded total. Of the recoveries, 652 (87·1 per cent) were shot. Included in the recoveries were 317 banded as males and 404 banded as females, a recovery rate (recoveries/banded) of 22·3 per cent for males and 17·7 per cent for females.

Table 2 compares the annual banding total of Black Ducks with recoveries made within a year and to the end of 1969. On average 14·2 per cent of birds banded in any year were recovered within 12 months, and 6·6 per cent subsequently. The data show that there has been little relationship between the size of any banded cohort and its eventual recovery rate. For Mountain Ducks, an average of 9·5 per cent were recovered within 12 months of release and 10·2 per cent subsequently.

The distribution of recoveries of Black Ducks shot on a known date within open seasons in Victoria is summarized in Table 3, where attention has been paid to totals reported for the first week of each season. Prior to 1958, season length varied from 89 days in 1952 to 62 days in 1955. However since 1958, seasons have been declared from the penultimate Saturday in February to the last in April (i.e. a length of between 63 and 71 days). The Table shows that from 1953 onwards an average of almost 40 per cent of recoveries have been made during the first week of a season, and 31 per cent on the first day of the season. For Mountain Ducks the respective figures are 34·5 and 28·5 per cent. Such figures are minimal since other recoveries were made during each season without accurate dates being provided.

(iv) DISPERSAL

Table 4 summarizes movement undertaken by Mountain and Black Ducks banded in Victoria and eventually recovered. Most recoveries of both species were made within 100 km (62·5 miles) of the banding site; 81·1 per cent of Black Ducks and 76·0 per cent of Mountain Ducks were recovered within 250 km (156·3 miles). The table also shows movements undertaken by adult and juvenile males. Whilst 57·6 per cent of juvenile Black Duck recoveries were within 100 km of the release site, only 41·8 per cent of adults were within this distance and respective figures for the 250 km

TABLE 2

Recoveries of Black Duck banded in Victoria between 1952 and 1969.

Year	Banded	Recovered			Percent Recovered	
		1st year	*Later*	*Total*	*1st year*	*Total*
1952	469	44	16	60	9·4	12·8
1953	1743	177	91	268	10·2	15·4
1954	231	41	13	54	17·8	23·4
1955	138	9	13	22	6·5	15·9
1956	180	32	16	48	17·8	26·7
1957	489	107	47	154	21·9	31·5
1958	112	31	7	38	27·7	33·9
1959	165	29	9	38	17·6	23·0
1960	152	30	18	48	19·7	31·6
1961	159	20	14	34	12·6	21·4
1962	158	27	14	41	17·1	26·0
1963	5	—	—	—	—	—
1964	430	73	46	119	17·0	27·7
1965	374	55	24	79	14·7	21·1
1966	406	58	25	83	14·3	20·4
1967	339	60	15	75	17·7	22·1
1968	22	4	—	4	18·2	(18·2)
1969	72	6	—	6	8·3	(8·3)
Totals	5644	803	368	1171	14·2	20·8

zone were 82·2 and 76·8 per cent. Young male Mountain Ducks moved less than did adults, thus 53·2 per cent of the juvenile recoveries were made within 100 km compared with 45·8 per cent of the adult male recoveries. Within 250 km of the banding site, 62·8 per cent of adult and 73·6 per cent of juvenile recoveries were made.

Fig. 1 shows the distribution of recoveries of Black Ducks banded in Victoria. The diagram also indicates the major river systems in Victoria and shows other features relevant to recovery locations. While dispersal is clearly widespread, it is apparent that movement is eastwards into the swamps and deeper waters around the Gippsland Lakes, to the west into Western Victoria and South Australia with some birds reaching the Lake Alexandrina area. There also appears to be a broader movement with birds dispersing widely into central and northern Victoria to the tributaries of the Murray and beyond. Some birds have been recovered in

TABLE 3

Recoveries of banded Black Duck in Victoria during open seasons, 1953–1969.
*(*No recoveries were made within the first week of 1952).*

Year	Number Recovered			Percent of Total	
	In season	*In first week*	*On first day*	*In first week*	*On first day*
1953*	111	17	9	15·3	8·1
1954	84	37	31	44·1	36·9
1955	36	17	14	47·2	38·4
1956	38	24	15	63·2	39·5
1957	54	26	18	48·2	33·3
1958	118	66	59	55·9	50·0
1959	35	19	18	54·3	51·4
1960	49	25	19	51·0	38·8
1961	39	12	9	30·8	23·1
1962	39	21	17	53·9	43·6
1963	24	14	10	58·3	41·7
1964	29	9	6	31·0	20·7
1965	70	19	16	27·1	22·9
1966	78	24	21	30·8	26·9
1967	62	26	20	41·9	32·3
1968	52	20	13	38·5	25·0
1969	26	1	0	3·9	nil
Totals	944	377	295	39·9	31·3

TABLE 4

Recoveries of Victorian banded Black Ducks and Mountain Ducks in relation to distance from banding sites. Details are given for all recoveries and comparison is made between males banded as adults and as juveniles.

	Distances in km							
	0–50	51–100	101–150	151–200	201–250	251–300	301–400	400+
BLACK DUCK								
All sex and age groups								
Number	551	120	99	101	196	67	81	97
Percent of total	41·9	9·1	7·5	7·7	14·9	5·1	6·2	7·4
Adult males								
Number	92	27	29	25	46	15	27	24
Percent of total	32·3	9·5	10·1	8·8	16·1	5·3	9·5	8·4
Juvenile males								
Number	82	16	15	8	19	8	9	13
Percent of total	48·2	9·4	8·8	4·7	11·1	4·7	5·3	7·6
MOUNTAIN DUCK								
All sex and age groups								
Number	256	116	53	44	71	71	42	58
Percent of total	36·0	16·3	7·5	6·2	10·0	10·0	5·9	8·2
Adult males								
Number	23	4	2	2	6	11	3	8
Percent of total	39·0	6·8	3·4	3·4	10·2	18·6	5·1	13·6
Juvenile males								
Number	17	17	6	3	4	1	9	7
Percent of total	26·6	26·6	9·4	4·7	6·3	1·6	14·1	10·9

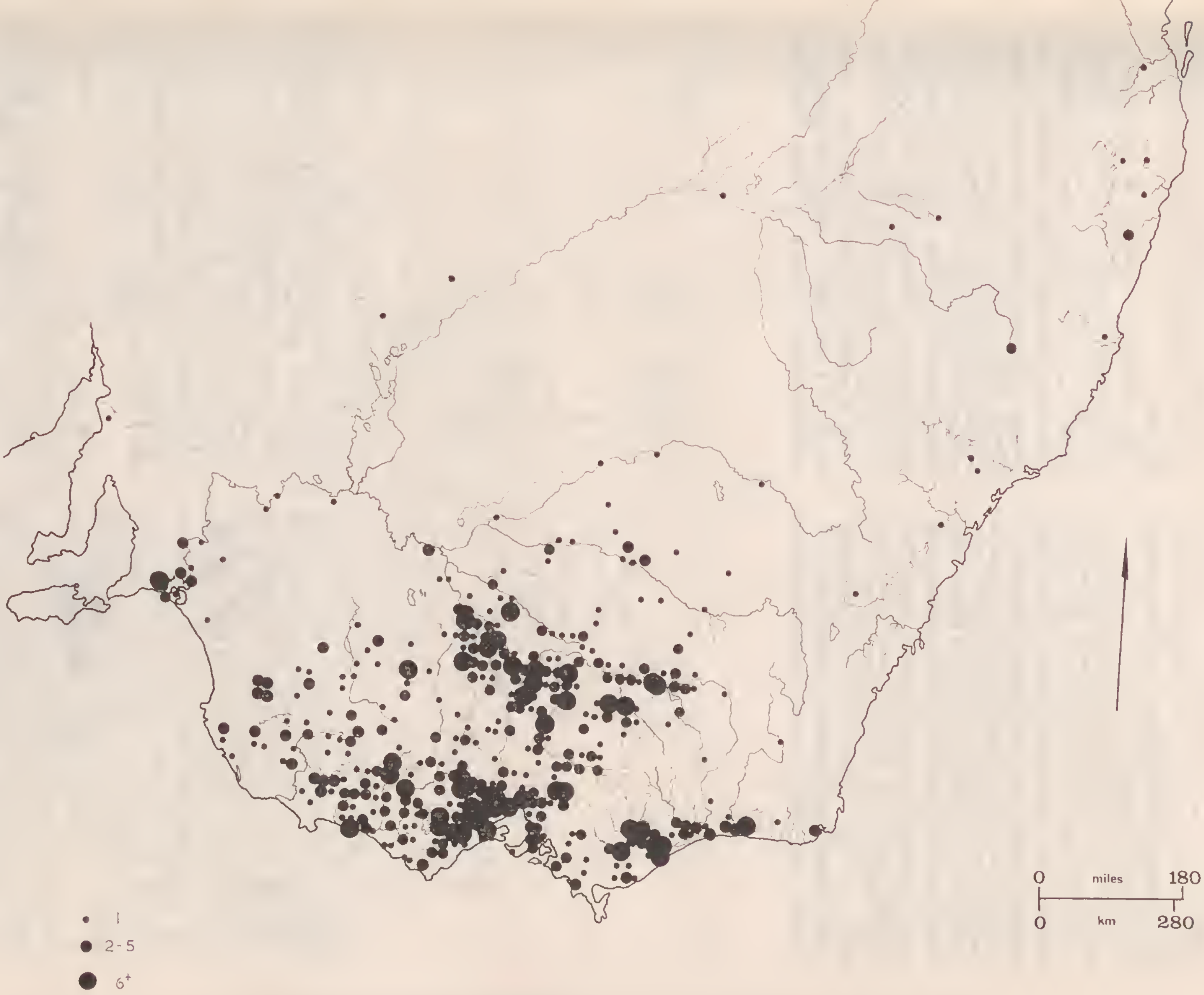

FIG. 1—Distribution of recoveries of Black Ducks banded in Victoria between 1952 and 1969.

Tasmania (42) and northern Queensland (2) and one, banded at Serendip, was recovered 25 months later at Otago in New Zealand, a distance of about 1900 km (1200 miles).

In 1953, 1181 Black Ducks were banded at Serendip. Fig. 2 shows the recovery pattern for 597 birds banded between January and March, and Fig. 3 the corresponding pattern for 584 birds banded between April and August. Recoveries in each case have been grouped into those made in 'summer' (November to March), 'winter' (April to August)and recoveries made after March 1955. Whilst recoveries made in the first summer period were concentrated around Serendip, some birds evidently moved far between January and March 1953. Dispersal was more widespread later and there was little evidence of return movements during second and subsequent summers. First summer recoveries of birds banded between April and August 1953 were generally away from Serendip and few recoveries were subsequently made in that area.

Fig. 4 shows the location of recoveries for Mountain Ducks banded in Victoria. Dispersal from the major banding sites (Lakes Martin and Rosine, and Serendip) has been predominantly northwards with birds being recovered widely throughout the inland plains of western and central Victoria. Many recoveries were made in the Lake Corangamite area, in the Gippsland Lakes region and around Lakes Albert and Alexandrina in South Australia and some birds (11) have also been recovered in Tasmania. But the diagram indicates that few Mountain Ducks banded anywhere in Victoria move beyond the Murray.

Fig. 5 presents recoveries of Mountain Ducks caught at Lakes Martin and Rosine during the periods January to March of 1960 and 1961 when

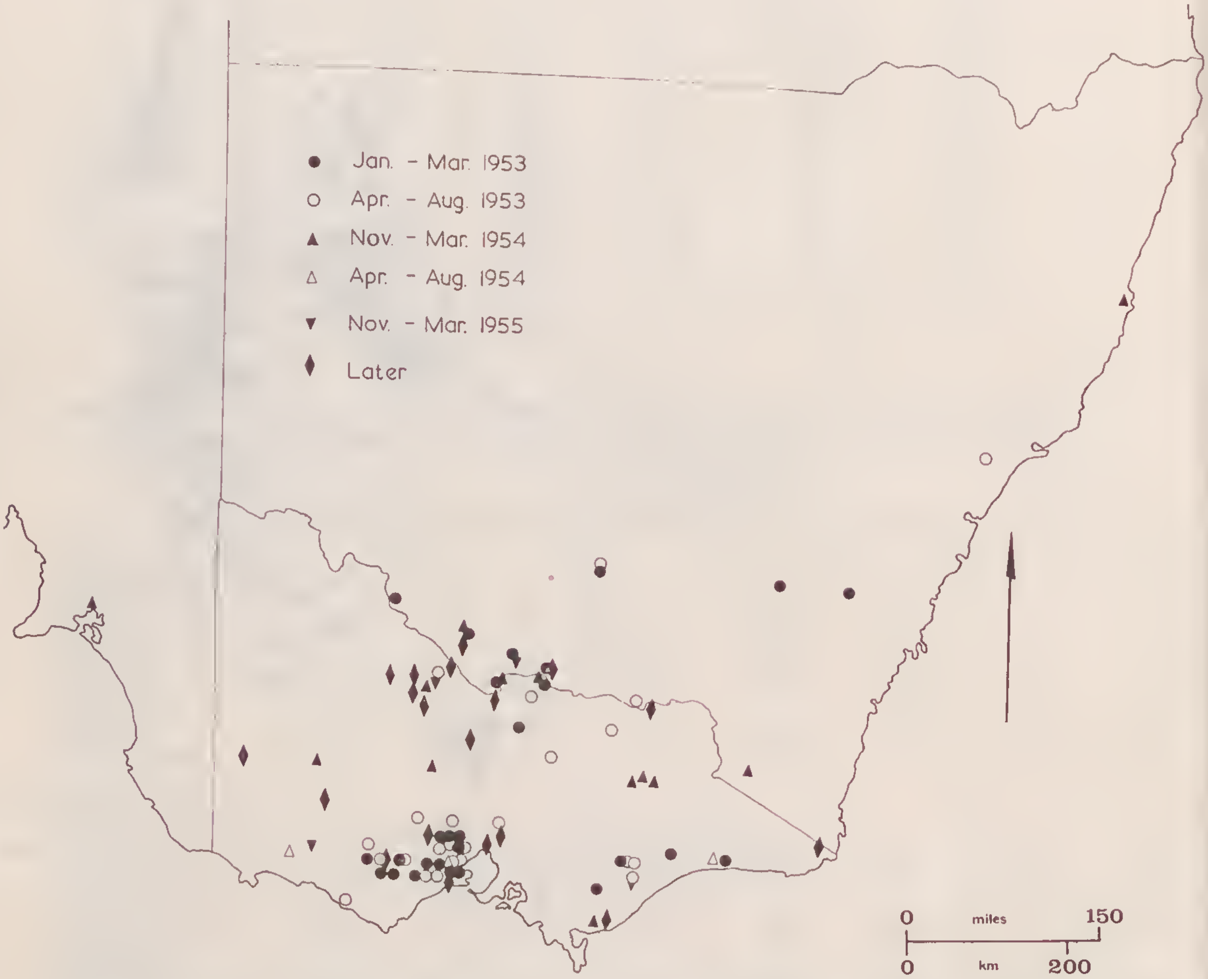

Fig. 2—Recovery locations of Black Ducks banded at Serendip between January and March 1953.

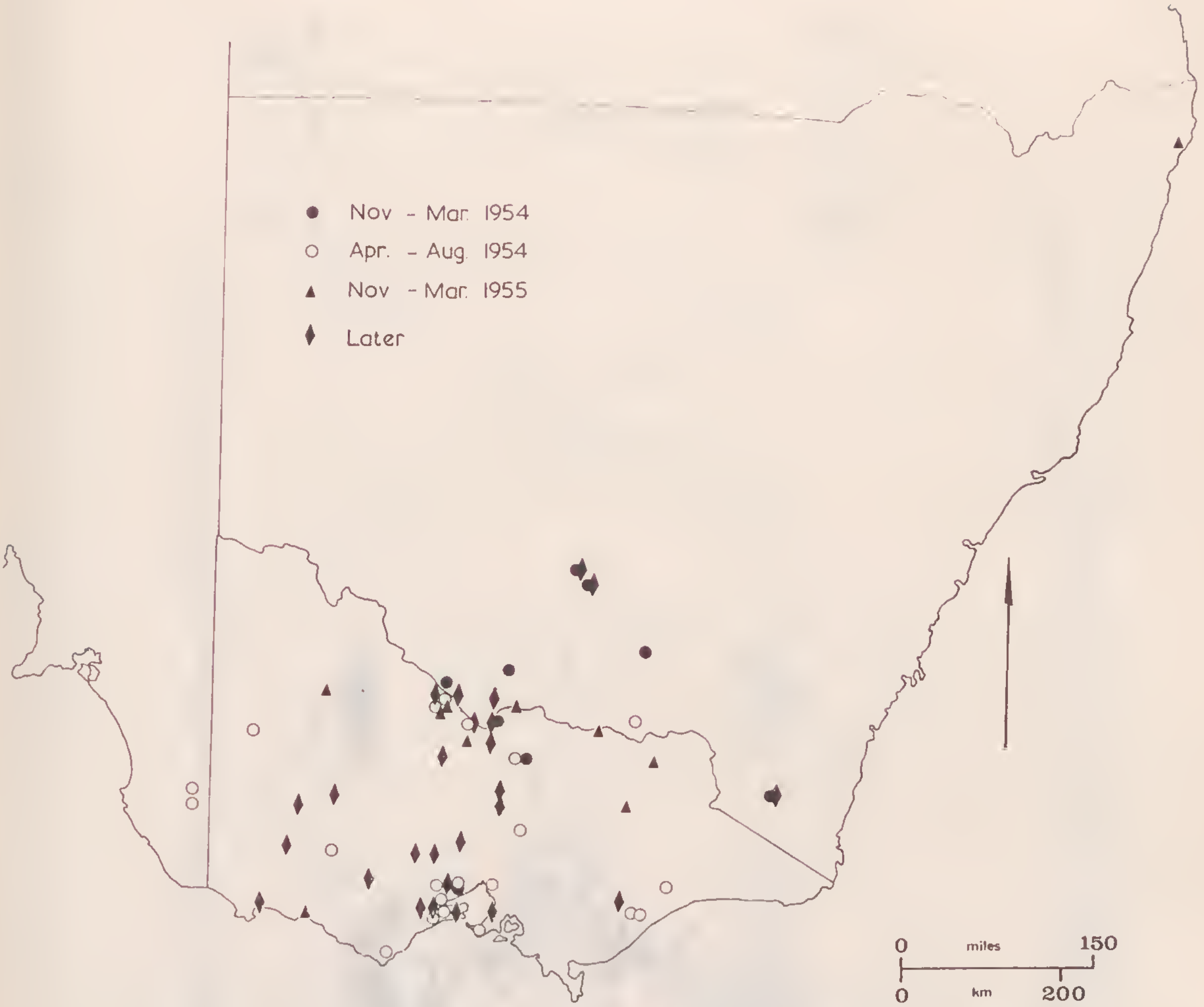

FIG. 3—Recovery locations of Black Ducks banded at Serendip between April and August 1953, and recovered from November 1953 onwards.

2168 birds were banded. Recovery totals for birds banded at both sites have been combined, since the sites were only about a mile apart and trapping was taking place at a time when large flocks occurred. The diagram distinguishes between 'summer' and 'winter' recoveries, again in an attempt to define the source areas of the birds congregating in the Lake Corangamite region. Recoveries to the end of March, for either year of banding, show that dispersal is widespread in the summer, though some birds were recovered near the banding site in the summer and winter months.

(v) MORTALITY

Recovery totals (for shot birds only) in year classes since banding are given for both species in Table 5, as are mortality and survival data based on percentages of bands returned. In this study 67·3 per cent of the recovered Black Ducks and 48·8 per cent of recovered Mountain Ducks were killed within a year of banding. Within four years 93·3 per cent mortality occurred in banded Black Ducks and 90·4 per cent in banded Mountain Ducks. The average mortality rate for Black Ducks in the 0-4 year period after banding was 47·4 per cent and the weighted mean mortality rate 56·7 per cent. Based on the latter figure, expectancy of life for Black Ducks of all sex and age groups was only 1·26 years post-banding. For Mountain Ducks average mortality in the four years following banding was 43·9 per cent and life expectancy 1·44 years, based on a weighted mean mortality rate of 49·1 per cent.

In Table 6, the mortality and survival data (based on weighted mortality rates) for various sex and age groups have been summarized. For both species, juvenile and female mortality is high and the corresponding life expectancy low.

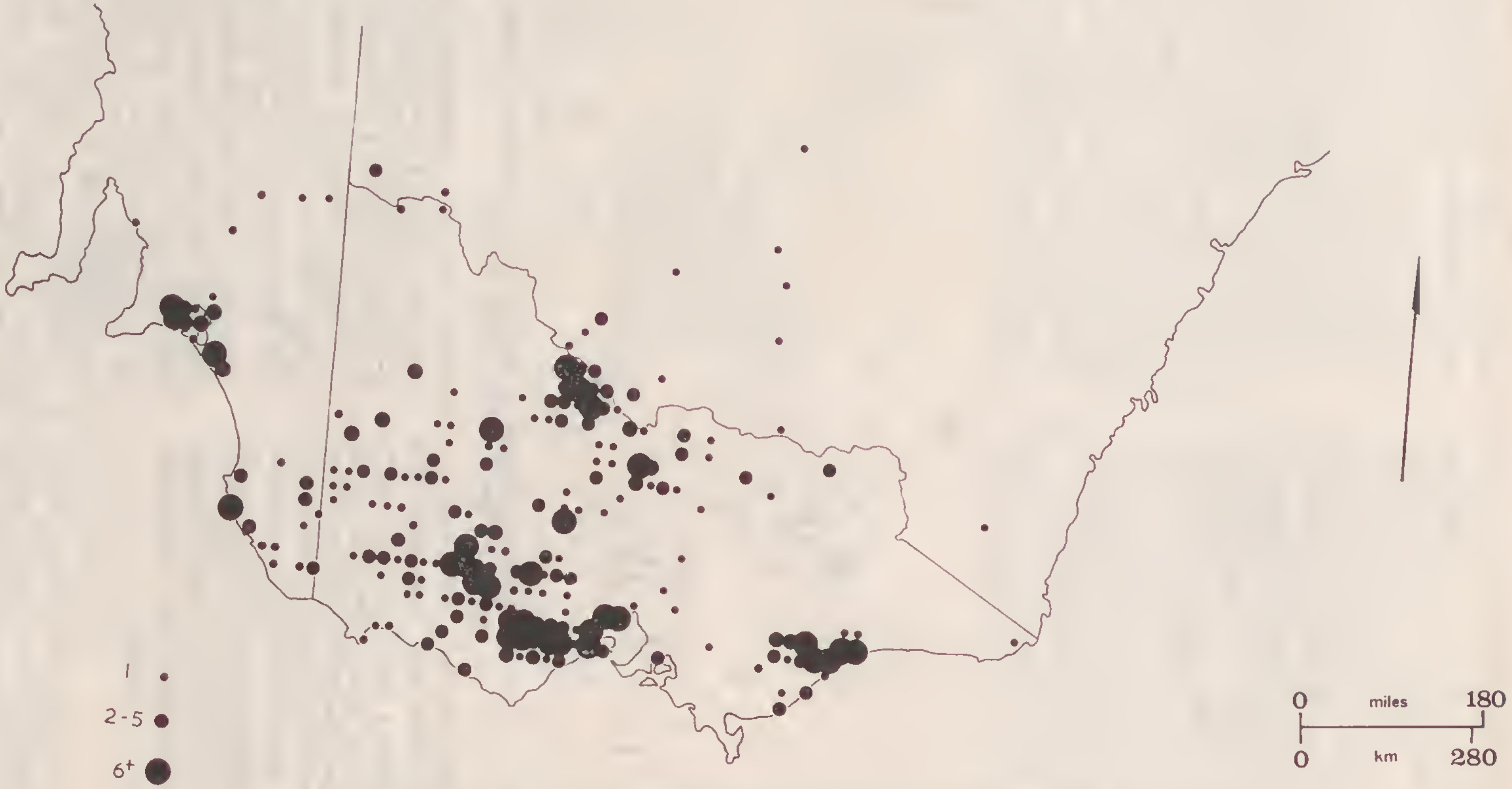

FIG. 4—Distribution of recoveries of Mountain Ducks banded in Victoria between 1954 and 1967.

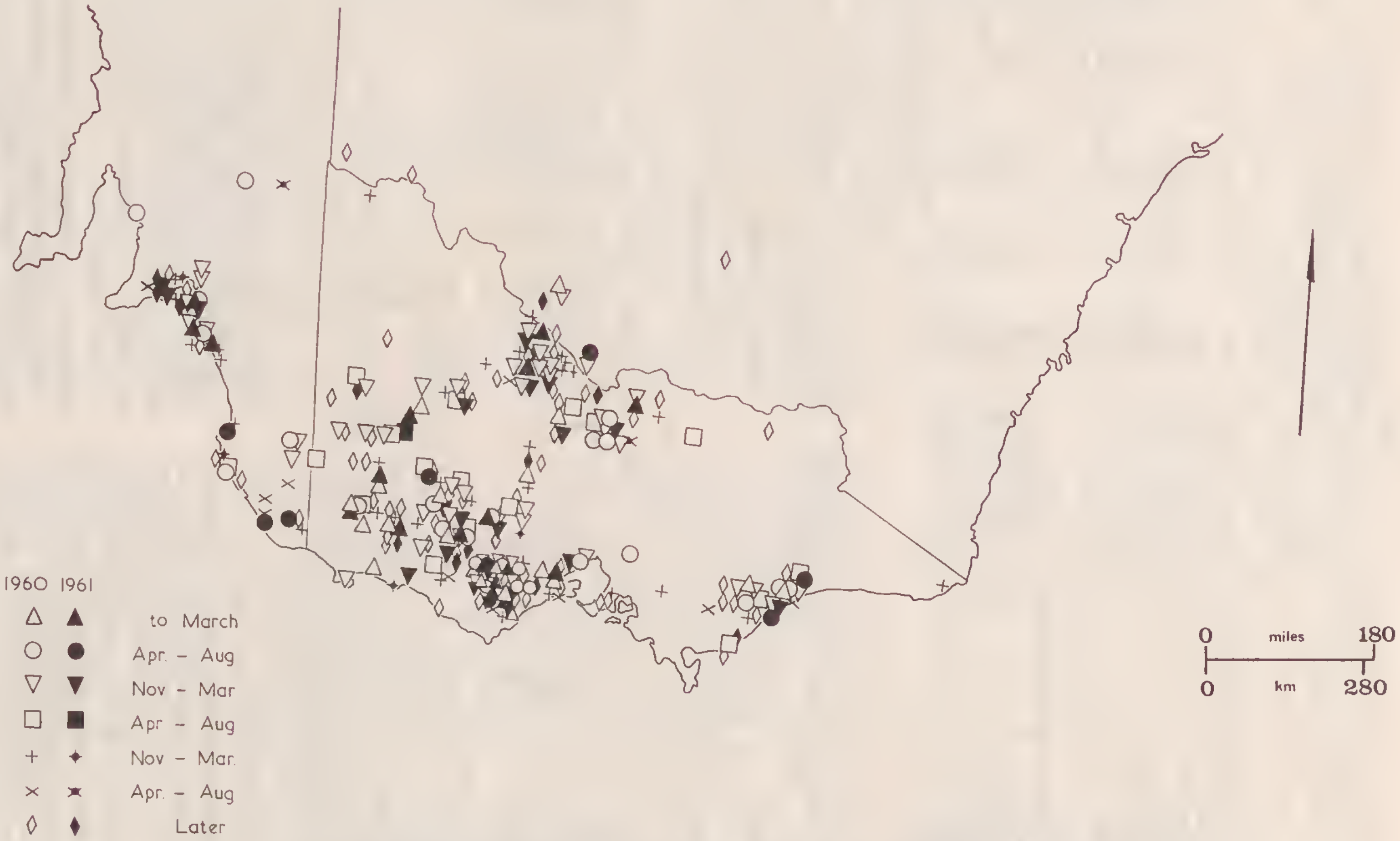

FIG. 5—Recoveries of Mountain Ducks banded at Lakes Martin and Rosine between January and March in 1960 (open symbols) and 1961 (closed symbols).

Table 5

Recoveries, by shooting only, of Black Ducks and Mountain Ducks banded in Victoria.

	Recoveries in years following banding						
	0–1	1–2	2–3	3–4	4–5	5–6	6+
Black Duck							
Total banded and available for recovery	5644	5572	5550	5211	4805	4431	4431
Total recovered	803	144	109	49	35	13	18
Percentage recovered	14·22	2·58	1·96	0·94	0·73	0·29	0·41
Mortality series	67·29	12·22	9·29	4·45	3·44	1·39	1·92
Cumulative recovery (%)	67·29	79·51	88·80	93·25	96·69	98·08	100
Survival series	32·71	20·49	11·20	7·75	3·31	1·92	nil
Mortality rate	67·3	37·4	45·3	39·7	(average 0–4 years = 47·4 % 1–4 years = 40·8 %)		
Mountain Duck							
Total banded and available for recovery	3798	3798	3790	3785	3755	3720	3720
Total recovered	319	132	74	65	33	16	13
Percentage recovered	8·40	3·48	1·95	1·72	0·88	0·43	0·35
Mortality series	48·83	20·20	11·35	9·98	5·10	2·50	2·03
Cumulative recovery (%)	48·83	69·03	80·38	90·36	95·46	97·96	99·99
Survival series	51·17	30·97	19·62	9·64	4·54	2·03	nil
Mortality rate	48·8	39·5	36·6	50·9	(average 0–4 years = 43·9; % 1–4 years = 42·3 %)		

Table 6

Mortality rates of various age and sex groups of Black and Mountain Ducks banded in Victoria between 1952 and 1969, as determined from shot recoveries.

Sex and age group	Number banded	Number recovered	Average mortality			Life expectancy (years)
			(Years after banding) 0–1	1–4	0–4 (Mean)	
Black Duck						
Juvenile male	629	158	73·5	43·5	50·8	1·09
Adult male	1096	272	57·3	48·4	50·6	1·38
All male*	2108	506	64·3	46·9	51·2	1·26
Juvenile female	303	69	75·7	35·6	45·6	1·10
All female*	2153	443	75·5	35·6	45·6	1·09
All birds†	5644	1151	67·3	40·8	47·4	1·26
Mountain Duck						
Juvenile male	232	56	51·5	54·8	54·0	1·48
Adult male	350	63	39·7	42·3	41·7	1·68
All male*	1422	270	47·8	40·6	42·4	1·55
Juvenile female	117	27	55·4	55·7	55·6	1·25
All female*	2278	357	48·6	45·7	46·5	1·52
All birds†	3798	652	48·8	42·3	43·9	1·44

* *Includes birds of unknown age.*
† *Includes birds of unknown sex and age.*

(vi) X-RAY EXAMINATION

Results obtained during fluoroscopic examination of 2296 Black Ducks at seven localities in Victoria between 1957 and 1969 are shown in Table 7, as are data collected from 3466 Mountain Ducks examined at six sites between 1958 and 1967. Most Black Ducks (1974, 85·9 per cent) were processed at Serendip and 86·2 per cent of the Mountain Ducks were processed at Lakes Rosine and Martin: totals have therefore been pooled for each species.

Of the Black Ducks examined, 13·8 per cent carried shotgun pellets and pellets were found in 22·3 per cent of Mountain Ducks. In both species adult males contained more pellets than did any other group. Most Black Ducks (62·3 per cent) and Mountain Ducks (55·6 per cent) carried only one pellet but a maximum of eight and 25 were recorded respectively.

(vii) SHOOTING MORTALITY AND PRODUCTION

As pointed out by Bellrose (1953, 1955) and Bellrose and Chase (1950), cripple loss, where birds are shot and die without being retrieved, and non-return of bands, affect recovery rates and

TABLE 7

Results of fluoroscopic examination of Black Ducks and Mountain Ducks trapped in Victoria between 1957 and 1969.

	Number examined			Number of pellets					
	With Shot	*Without Shot*	*Percent With Shot*	1	2	3	4	5	6
BLACK DUCK									
Juvenile males	19	442	4·12	14	2	2	1	—	—
Adult males	143	652	17·98	84	36	11	7	2	3
All males*	176	1112	13·66	104	41	15	10	2	4
Juvenile females	1	117	0·85	1	—	—	—	—	
All females*	129	851	13·16	87	23	13	3		3
All birds†	316	1980	13·76	197	68	28	13	2	8
MOUNTAIN DUCK									
Juvenile males	29	202	12·55	20	6	1	1	—	1
Adult males	87	266	24·64	53	14	7	4	2	7
All males*	309	1022	23·21	173	55	40	18	6	17
Juvenile females	9	79	10·22	6	2	—	—	—	1
All females*	459	1665	21·61	257	94	56	21	13	18
All birds†	773	2693	22·30	430	149	96	39	19	40

* *Includes birds of unknown age.*

† *Includes birds of unknown sex and age.*

hence mortality estimates. No information is available to gauge the importance of such factors in Australia apart from that of Lavery (1969), who showed a 14 per cent loss for Black Ducks shot in Queensland, but Balham and Miers (1959) approximated a 12 per cent cripple loss and 20 per cent non-return of recovered bands in New Zealand. In Victoria a prize system (of 'lucky bands' preselected prior to the shooting season) has operated since 1958 and perhaps has maintained a fairly constant proportional rate of band return. However, as shown in Table 2, recovery rates in the year post-banding are variable and probably relate closely to local wetland conditions and waterfowl availability.

Application of Balham and Miers' estimation implies that some 27·5 per cent of banded Black Ducks and 22·6 per cent of Mountain Ducks die from shooting.

Estimates of productivity necessary to maintain population levels may be obtained from $x = Mw/50(1-M)$, where x is the number per pair, M is the first year mortality and Mw equals annual loss per 100 adults (Balham & Miers 1959). Substitution, using the more extensive data for males, shows that each Black Duck pair must raise four young, and Mountain Ducks two young, to the flying stage each year to sustain the present shooting pressure.

DISCUSSION

The distribution of recoveries of banded waterfowl is mostly dependent on habitat distribution, habitat quality and the consequent shooting, which probably is of an even density throughout south-eastern Australia. Thus the recovery locations shown in Figs. 1 and 4 reflect general habitat requirements available to the two species.

Black Ducks banded in Victoria, particularly at Serendip, have been recovered widely in the State on river systems and the more permanent wetlands. In general dispersal has been towards the Murray and its tributaries, to Gippsland and to Western Victoria and South Australia. Movement (Table 4) has been slightly more pronounced than that recorded for the species banded elsewhere. In this study 51 per cent were recovered within 100 km of the banding site, compared with almost 69 per cent recovered in the same distance in South Australia (Norman 1971a), and Frith (1967) showed a 58 per cent recovery within 50 miles (80 km). Juvenile birds, being apparently more prone to shooting, are recovered closer to banding sites than adults. Although recoveries of Black Ducks banded in 1953 at Serendip showed that a small number resided in or around the banding area permanently, most dispersed widely after banding (Figs. 2 and 3). There was no evidence of a return movement and it is apparent that in that area 'local' birds were joined by others, moving perhaps in response to decreasing water levels (see also Ford 1958) to congregate in summer, and later disperse. Morgan (1954) showed a similar pattern at Altona, about 30 km from Serendip. Banding in Victoria and in South Australia (Norman 1971a) did not indicate a movement southwards in summer, northwards in winter, as found for birds banded in inland Australia (Frith 1963).

Mountain Ducks also increase in numbers during summer months at Altona, and it was suggested that dispersal into Western Victoria took place in spring months (Morgan 1954). Indeed Frith (1967) suggested that Mountain Ducks in south-eastern Australia showed a regular movement with large congregations occurring in certain areas following breeding. Dispersal from such flocks, in which moulting takes place, results in birds returning to breeding areas (Frith 1967).

In the period encompassed by this study most birds were banded at summer congregations in Western Victoria and birds moved to be recovered generally northwards of the banding station, in areas where breeding is assumed to occur (Frith 1967). The distribution pattern of recoveries of Mountain Duck (Fig. 4) indicates that the species is widely dispersed throughout the central and western plains in Victoria and in the Gippsland wetland systems. It is notable that few birds were recovered in the higher eastern regions and none were obtained in the northern Mallee. Some birds apparently move from breeding sites in Tasmania to summer congregations in Victoria, since recoveries in the reverse direction have occurred. Such congregations seem to occur annually: seasonal population changes occur in the Lake Corangamite area with summer maxima and this resembles events in moulting areas elsewhere, as described by Frith. Some interchange may take place between moulting areas since it is known (H. Wright pers. comm.) that moulting takes place in the Lake Wellington area, Gippsland, and recoveries of birds banded in summer flocks in the Western District have been shot in summer near Lake Wellington. Certainly very few (two out of 1698) birds trapped in one summer period at Lakes Martin or Rosine were retrapped at the same location in the next summer.

The majority (52·3 per cent) of banded Mountain Ducks were recovered within 100 km, 66 per cent within 200 km and 86 per cent within 300 km, a result similar to that reported for Mountain Ducks banded in South Australia (Norman 1971a). Few birds banded in Victoria or South Australia moved more than 400 km, and the movements of both Black Ducks and Mountain Ducks are much more restricted than those reported for Grey Teal (Frith 1963, Norman 1971a).

Mortality rates shown in Tables 5 and 6 indicate that 67·3 per cent of recovered Black Ducks and 48·8 per cent of Mountain Ducks died within a year of banding; 93·3 per cent of Black Ducks and 90·4 per cent of banded and recovered Mountain Ducks were dead four years after banding. In South Australia Black Duck mortality was lower in the year post-banding (55·3 per cent) but within four years 95·7 per cent mortality had occurred, and life expectancy was slightly longer (1·36 years) than that of 1·26 years recorded for Victorian banded Black Ducks (Norman 1971a). Frith (1963) presented similar data but Balham and Miers (1959) showed a 73·6 per cent mortality in the year following banding, a rate equalled in this study by juvenile males and exceeded by females (Table 6). Mean mortality was higher in the females banded in New Zealand (Balham & Miers 1959) and during this study, but Frith (1963) found that the males showed the higher mortality.

Mortality data for the Mountain Duck banded in Victoria differ from those given for birds banded in South Australia. There, although an average of 43·7 per cent mortality occurred in the four years following banding (cf. 43·6 per cent in Victoria), first year post-banding mortality was lower (43·98 per cent compared with Victorian 48·8 per cent) and life expectancy longer (1·79 years compared with 1·44 years). Although Frith (1967) stated that the Mountain Duck was not considered to be a good game species, it is clear that many are shot in Victoria.

Both absolute and relative recovery rates have been high during this study. To the end of 1969, 25·9 per cent of Black Ducks and 19·7 per cent of Mountain Ducks banded in Victoria have been recovered and of these 20·8 and 17·4 per cent were shot. By comparison Frith (1963) gave a return rate of 13·2 per cent for Black Ducks banded mainly in New South Wales. Norman (1971a) showed that 24·5 per cent of Black Ducks banded in South Australia were recovered, 21 per cent by shooting and 18·5 per cent of the Mountain Ducks banded there were recovered, 15·2 per cent by shooting. In New Zealand, Balham and Miers (1959) reported that some 34 per cent of banded Black Ducks were shot and recovered with 25·2 per cent being shot within a year of banding (cf. 14·2 per cent this study; 7·15 per cent Frith 1963).

Table 6 shows that life expectancy is greater in males and that juvenile birds undergo a greater post-banding mortality than do adults. If fluoroscopic examination results (Table 7) are representative of shooting pressure then males, which carry more shot pellets than do females, must be subject to more hunting. Juvenile birds, which have a lower life expectancy and a lower shot content than older birds may be more prone to shooting than the more experienced adults, and consequently survival (and shot content) is reduced. The difference in shot content between males and females, also found in ducks and geese in Europe and America (Elder 1950, 1953), may relate to size differences, but there may be additional mortality factors affecting female survival in or after the breeding season, or outside the hunting season (Balham & Miers 1959, Bellrose & Chase 1950). Apart from three years (Table 1) sex ratios for Black Ducks caught at Serendip have been in favour of males, and although this could have resulted from a trapping bias (Bellrose & Chase 1950) or a higher initial proportion of males (Petrides 1944), it may relate to the higher female mortality.

Natural productivity in a stable population subjected to hunting must be sufficient to allow for this additional mortality factor, which presumably will show a proportional increase as habitat decreases through drought or drainage. Productivity estimates presented here have been based on mortality data gained from recovery of banded birds. No information is available in Victoria regarding clutch size, hatching success, or survival of young to breeding for Black Ducks or Mountain Ducks, and it is clear that a more detailed knowledge of such aspects is required for further elaboration of data. Frith (1967) considered that most Black Duck nests held 8 to 10 eggs with clutches averaging 9·1 eggs and since each pair must raise four young annually to allow mortality to continue at rates shown in this study, then reproductive efficiency must be maintained at about 44 per cent. Lavery (1970) showed that for a small sample of broods of Black Ducks in northern Queensland there was an average of 2·0 ± 1·06 in the 'old flapper' stage. Mountain Ducks usually have between 10 and 14 eggs, but variation between 5 and 22 have been reported (Frith 1967) and the production of two young each year by a pair would appear within the species' capability. For the Black Duck, no data are available regarding brood size and success. Population levels could of course be supplemented by birds moving in from other states.

Levels of productivity for a game species depend on several factors including maintenance of breeding habitats with adequate nutritional reserves, and will be affected by the extent of shooting pressure to which the species is subjected. Detailed understanding of species' ecological requirement is required if breeding or, as with Mountain Duck, moulting habitat is to be maintained. The results obtained in this study suggest that neither species is declining as a result of shooting pressure. However, it is possible that destruction of habitat may in itself increase shooting pressure. Table 3 shows, for the Black Duck, that reductions in shooting kill may be achieved by restrictions in allowable bag limits during the early part of the shooting season. Further, since both species move to some extent beyond Victoria, maintenance of the species depends on co-operative measures at the interstate level.

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